MONTANA PEST RISK ASSESSMENT
Japanese Beetle, *Popillia japonica*
(Coleoptera: Scarabaeidae)
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I. Introduction

A. General

The family Scarabaeidae contains several pest insects, including a number that are pests of turf grass as immatures (white grubs) (White 1983). One of these, the Japanese beetle (*Popillia japonica*), is reputed to be the most injurious species in the entire family (White 1983). This medium-sized, green and copper metallic colored beetle is frequently encountered feeding in groups in the eastern United States (Figure 1). The Japanese beetle was introduced to North America in 1916 (Fleming 1972), and spread rapidly throughout the eastern U. S. At the present time, it is found in almost every state (Figure 2), although it may not be listed as established in some states.

Figure 1. White grub, similar to Japanese beetle immature, and Japanese beetle adult.

Japanese beetle has a wide host range. It is somewhat unusual in that both the adults and larvae are considered pests (Cranshaw 2004). The larvae feed on numerous species of plant roots, preferring grasses including Kentucky bluegrass, a primary lawn grass, and corn (*Zea mays*). The adults feed primarily on broad-leaved plants, with some preference for species in the Rosaceae family (Fleming 1972).

B. Risk Assessment Use

This risk assessment will be used by the Montana Department of Agriculture (MDA) to identify and prioritize the risk of establishment of Japanese beetle in Montana. In addition, identifying areas of the state with a high risk of establishment of Japanese beetle will provide accurate information for surveys and monitoring by field staff. The MDA has primary responsibility for excluding, eradicating, and assisting in the management of exotic or invasive plant pest species that threaten Montana's environment or agriculture.

C. Previous Risk Assessments

There are relatively few formal risk assessments for Japanese beetle, in part because it is a widespread pest that is expected to attain national distribution.

The National Plant Board risk assessment (http://www.nationalplantboard.org/policy/jbcolumn.html#_Toc67035365) indicates that Japanese beetle can be expected to expand into most areas that are ecologically appropriate. This includes many extensively managed areas such as lawns and other turf grass areas. However, the risk of establishment is relatively low in areas with low rainfall (under 10 inches / year), and with soil temperatures below 9.4^{o} C. Accordingly, most Montana rangeland is not at risk for establishment of the beetle. However, farmland, particularly in the lower river valleys, is at a higher risk, due to the fact that these areas are already more amenable for cropping, and growth of high risk plants, and also due to the increased water in the soils in these areas due to irrigation.

Although it is not a risk assessment, an Emergency Amendment of Section 3589 of the California Code (http://www.cdfa.ca.gov/phpps/plantregs.htm#JB) brings forth situations considered by the California Department of Agriculture to pose special risks for establishment of Japanese beetle, namely, discovery of more than one adult beetle in a pheromone trap, in an area containing suitable host material. In addition, this document indicates that the adult beetle is capable of flights of up to five miles. The incident prompting an emergency eradication program took place in San Diego County, at considerably lower latitude than any portions of Montana.

Because Japanese beetle is capable of spreading rapidly once established, and has a very wide host range, the potential economic and environmental damage in Montana is high. Montana river bottoms tend to be farmed extensively or managed as riparian recreational areas. These recreational areas contain large numbers of plants in the rose family, and numerous grasses, which are the preferred food for the adult beetles and larvae. Displacement of native insects, as well as potential damage to the native plant community could take place. Potential for movement of Japanese beetle in mountainous regions is as yet unknown. While the beetle does occur in some mountainous eastern states, movement in the more extreme mountains of the western U.S. has not yet been observed. There is a possibility that mountain ranges may present barriers for natural beetle movement. However, movement via human conveyance has always been a major concern with Japanese beetle.

Our risk assessment is specific for Montana, and takes into consideration possible Montana hosts at risk, our economic factors related to those hosts and the movement of potential hosts of the Japanese beetle, and possible management factors to reduce the likelihood of further establishment and spread of Japanese beetle in Montana.

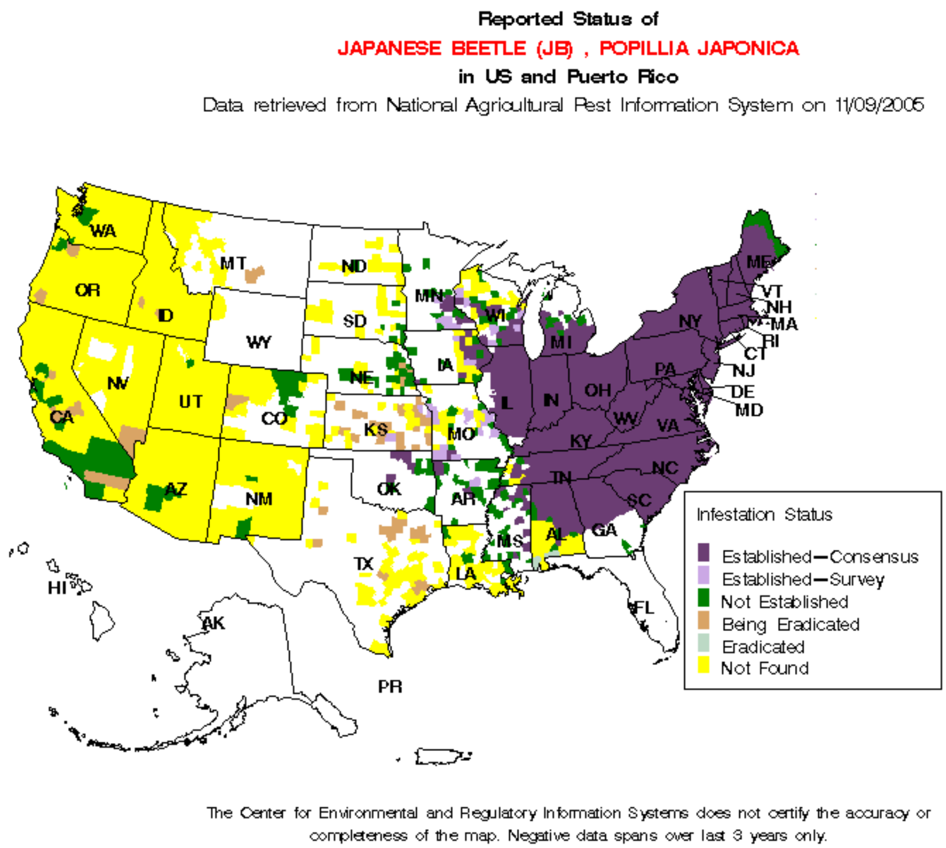

Figure 2. Current distribution of Japanese beetle (Popillia japonicus) in the United States.
http://ceris.purdue.edu/napis/pests/jb/imap/jball.html

II. Summary of Findings

Consequences of Invasion

Element	Rating	Score
1. Potential geographic distribution	**Medium/high**	**2.5**
a. Host range[a]	**High**	**3**
b. Climate suitability[a]	**Medium**	**2**
2. Dispersal potential	**Medium**	**2**
3. Potential abundance	**High**	**3**
4. Economic impact	**High**	**3**
5. Environmental impact	**Medium**	**2**
6. Health impact	**Negligible**	**0**
7. Social and political impact	**High**	**3**
8. Management	**Medium**	**--**
Subtotal (/Standard)		120/48

[a] Contributes to the assessment of potential geographic distribution

Likelihood of Invasion

Element	Rating	Score
1. Pest history	**High**	**108**
2. Quantity of commodity imported	**Medium**	**2**
3. Estimated pest density/unit imported	**Low**	**1**
4. Likelihood of surviving treatment	**Medium**	**2**
5. Likelihood of surviving shipment	**Medium**	**2**
6. Likelihood of moving to a suitable climate	**Medium**	**2**
7. Likelihood of finding a host	**High**	**3**
8. Potential for eradication	**Medium**	**2**
Subtotal (/Standard)		156/72
Overall Risk		**541.78**

Highest overall risk score possible 1856.25

III. Summary of Risk Assessment Methods

This document is modeled after a risk assessment prepared by the Minnesota Department of Agriculture and the USDA Forest Service (Selness and Venette 2006). As such, it uses the same methodology given in that document.

A numerical risk score was calculated by converting the rating of each element to a score (negligible=0; low=1; medium=2; high=3). Overall risk is the product of the consequences and likelihood of invasion. Unmitigated consequences of introduction follow the formula C = G x D x A x (Ec + En + H + S), where C is the total consequences; G, potential geographic distribution; D, dispersal potential; A, potential abundance; Ec, economic impact; En, environmental impact; H, health impacts to humans and vertebrates; S, social and political impacts. This regional assessment includes a rating of management potential, an indication of the availability and effectiveness of control options for the pest, but this rating is not included in the evaluation of consequences. The unmitigated probability of invading, I, is I = PH + (Q x P X Sp x Ss x M x F), where PH is the pest history of the organism, Q, quantity of host material imported annually; P, estimated density of pest per unit imported; Sp, likelihood of surviving treatment; Ss, livelihood of surviving treatment; M, the likelihood of being moved to a suitable habitat; and F, the likelihood of finding a host. Pest history is nearly as important as the existence of known pathways because new, unforeseen pathways for the introduction of a pest may arise in the future. As a result, rating for pest history are converted to scores using a slightly different system (negligible=0; low=12; medium=36; high=108). The assessment also includes a rating of the potential for eradication, but this rating does not factor into the calculation of the likelihood of invasions. Overall risk is calculated as (C/48*(I/72)*100. The highest possible risk score, using these numbers, is 1856.25.

IV. Pest Risk Potential

A. Consequence of Invasion

1. Potential Geographic Distribution: Medium/high

Popillia japonica is likely to find suitable host plants and habitat primarily in Montana's river bottoms and irrigated farmlands. Of particular concern are the Yellowstone River Valley and the Flathead Lake area, as well as the Bitterroot Valley and Missoula. Although these areas comprise less than 50% of Montana's land area, they contain concentrations of high value agriculture, including cherries and other fruit in the Flathead and Bitterroot, and soybeans and corn in the Yellowstone River Valley. In addition, these areas contain the highest population densities, and thus, heavily managed ornamental areas. These areas are generally lower in elevation with higher temperatures and rainfall than most areas of the state.

a. Host Range Rating: High

Popillia japonica has been recorded as feeding on over 400 species of plants. However, it prefers feeding on only 47 of the 400. (http://www.nationalplantboard.org/policy/jbcolumn.html#_Toc67035365). These include apples (*Malus* spp.), cherry (*Prunus avium* and *P. cerasus*), soybean (*Glycine max*), roses (*Rosa* spp.), and corn (*Zea mays*), which are grown in varying quantities throughout Montana, in the areas of mentioned above. In the Billings area, various ornamental and fruiting plants in the rose family are at high risk. Moving east and down the Yellowstone River Valley, agricultural plantings of both corn and soybean are at risk. In the western portion of the state, ornamental and commercial plantings of various fruit trees, including apples and cherries, are at high risk.

Climate Suitability Rating: Medium

Japanese beetle is restricted by both rainfall and minimum temperature. Dry conditions during the egg and larval stage can lead to desiccation and death, and may impact pupal development as well (Fleming 1972). Many parts of Montana managed as rangeland are thus not at risk for establishment of Japanese beetle. However, much of Montana's agricultural land is in areas where climatic conditions could allow Japanese beetle establishment, particularly if any localized adaptation were to occur. In addition, human management and environmental modification in the urbanized areas could lead to ideal conditions in terms of moisture due to irrigation practices. (Figure 3.)

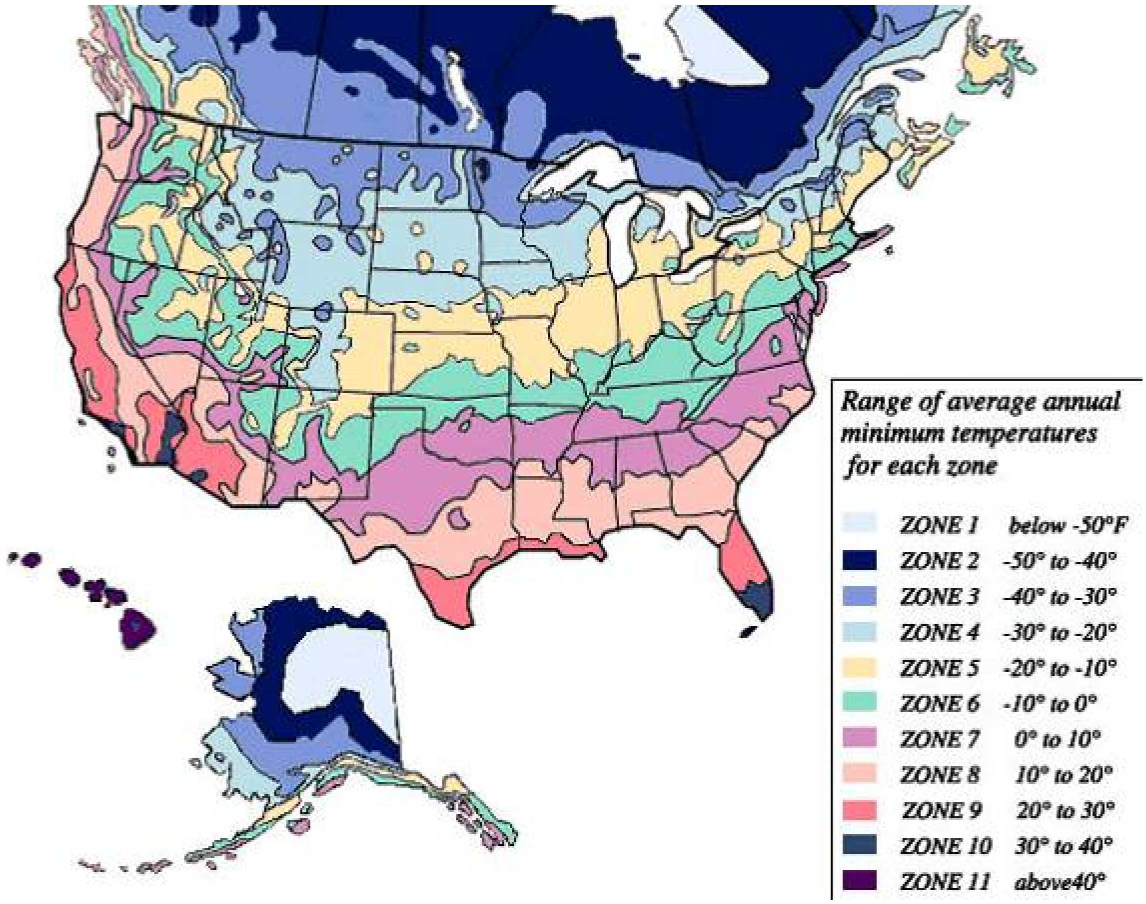

Figure 3. Climatic regions of the United States. Japanese beetle is found in all climatic zones in the United States, on this map. From http://us.st11.yimg.com/us.st.yimg.com/I/allthingsiris_1894_8895855.

Thus far, Japanese beetle has spread to most of the contiguous states (Table 1). A majority of the states where Japanese beetle has become highly prevalent are in the east, and southeast, but isolated pockets of infestation occur in most areas where conditions are ideal. As the beetle establishes in these pockets, localized adaptation may occur, followed by range expansion.

Table 1. Current distribution of Japanese beetle in the United States. States which have the beetle present in many counties are designated as "Present", those with only a few counties recorded as having the beetle as "Limited", and those in which the beetle has not been detected as "Absent", with the exception of Florida, where surveys are not performed, but all surrounding states are infested. http://ceris.purdue.edu/napis/pests/jb/imap/jball.html

State	Present/Absent	State	Present/Absent
Alabama	Present	Montana	Limited
Alaska	Absent	Nebraska	Present
Arizona	Limited	Nevada	Limited
Arkansas	Present	New Hampshire	Present
California	Present	New Jersey	Present
Colorado	Present	New Mexico	Limited
Connecticut	Present	New York	Present
Delaware	Present	North Carolina	Present
Florida	Present	North Dakota	Absent

Georgia	Present	Ohio	Present
Hawaii	Absent	Oklahoma	Present
Idaho	Limited	Oregon	Limited
Illinois	Present	Pennsylvania	Present
Indiana	Present	Rhode Island	Present
Iowa	Present	South Carolina	Present
Kansas	Present	South Dakota	Limited
Kentucky	Present	Tennessee	Present
Louisiana	Present	Texas	Limited
Maine	Present	Utah	Limited
Maryland	Present	Vermont	Present
Massachusetts	Present	Virginia	Present
Michigan	Present	Washington	Limited
Minnesota	Present	West Virginia	Present
Mississippi	Present	Wisconsin	Present
Missouri	Present	Wyoming	Absent

2. Dispersal Potential Rating: Medium

Japanese beetle originated in Japan, where the population is apparently held in check not only by natural enemies, and also by the availability of suitable habitat and host material (Pfadt 1978). In the United States, individual beetles have been recorded as moving up to 2 ½ miles per day, and capable of sustained flight for up to five miles (Fleming 1972). Generally, movement appears to be on the order of five to ten miles per year, in terms in infestation (Fleming 1972). The beetle appears to move more rapidly in areas with relatively flat terrain, such as broad, flat river valleys (similar to the Yellowstone River Valley) (Fleming 1972). On the other hand, topographical features such as mountains appear to impede the movement (Fleming 1972). The large expanses of rangeland that make up much of Montana may also pose a challenge for the beetle in terms of movement. Unfortunately, movement of not only the beetle, but also its host materials, and even incidental movement of individual beetles in conveyances, must also be taken into account. Production of most of Montana's landscape material is in only a few areas, with subsequent movement to other portions of the state, while routine movement of humans over hundreds of miles also occurs.

3. Potential Abundance - Reproductive Rating: High

Japanese beetle has a high reproductive potential. Although each female lays only a few eggs at a time, a total reproductive output of over 100 eggs can occur (Fleming 1972). The beetle may produce an aggregation pheromone (Cranshaw 2004), or respond to the presence of plant volatiles in wounded plants (Loughrin, et al, 1996), which increases the possibility of high populations in areas with acceptable hosts. In most areas, the life cycle of the Japanese beetle requires a single year for completion, although some authorities indicate that it is possible for the beetle to extend the life cycle to two years in the more northern portions of the range (Cranshaw 2004). In a worst case scenario, a single female could produce about 50 females per year.

4. Economic Impact Rating: High

Japanese beetle has little preference in terms of host plants. The larvae feed on a wide variety of grass roots, and can feed on other plant roots. The adults prefer to feed on rose family plants, but

will feed on a very wide variety of hosts (Fleming 1972, Pfadt 1978, Cranshaw 2004). While the primary effect is generally on horticultural plantings, invasion of this beetle into orchard areas such as the Flathead and Bitterroot Valleys could potentially be devastating. Adult feeding on the silks of corn can lead to decreased pollination, leading to incomplete ear filling, which could pose a difficulty in the lower Yellowstone River Valley in commercial corn production areas.
Of equal importance to the actual feeding damage are the costs due to regulatory concerns. Japanese beetle is currently a pest of quarantine significance in many of the western states, including Montana. Plant materials moving from infested areas must be certified as free of the pest.

5. Environmental Impact Rating: Medium
Japanese beetle has a potential for a medium environmental impact. A majority of the impact of this insect would be in areas that have been extensively modified for human use, including both agricultural and urban landscapes. Within these areas, however, the potential impact of the Japanese beetle is quite high. In addition, the potential impact of Japanese beetle in specific areas, such as the Yellowstone River Valley and the Flathead/Bitterroot Valleys, is high due to the non-specific feeding habits of both the adults and the immatures.

Feeding by the immature beetles can contribute to mortality of various grasses, particularly in lawn situations (Pfadt 1978). Adult feeding can likewise contribute to plant mortality through repeated defoliation. In wild river bottoms, this feeding and subsequent mortality could easily be accentuated by other environmental conditions, such as drought and flooding. However, the primary effect of the adult feeding is cosmetic.

In a recent study, Sadof and Sclar (2002) found that public tolerance to defoliation and other damage was generally low. Defoliation in the range of < 10 % is somewhat acceptable, high levels are not, whether the plants are in the yard, for viewing, or for sale.

It is unknown if Japanese beetle will impact any threatened or endangered species within the state. Certainly, due to its wide host range, the potential for feeding on such species does exist, particularly in the lower elevations and river bottoms.

6. Vertebrate Health Impact Rating: Negligible
The only impacts on human health that might occur due to Japanese beetle are emotional impacts on people whose yards and businesses are impacted by the cosmetic and economic damage caused by the beetle feeding.

7. Social and Political Impact Rating: High
Japanese beetle feeds on a large number of desirable plants. Much of its impact is cosmetic, in urban settings. In Montana, many of these plants are of high value to their owners. This can lead to emotional distress and political feedback. In addition, this insect is a pest of quarantine significance. Direct social impacts as a result of economic damage may also occur, particularly if the insect invades agricultural areas with high value crops such as fruit (the Flathead and Bitterroot Valleys).

8. Management Rating: Medium
In small, localized infestations, Japanese beetle is manageable. However, under ideal conditions for the beetle, extremely large populations can develop. Currently there are a number of insecticides

available for use against the larvae. In addition, milky spore disease (*Bacillus popilliae*) has been available for many years (Pfadt 1978). Several natural enemies, including tachinid flies and two tiphiid wasps (*Tiphia popilliavora* and *T. vernalis*) also attack the beetle. A number of entomopathic nematodes also attack JB (Cappaert and Smitley 2002, Mannion, et.al. 2000).

Although companion planting is often touted as a method for minimizing damage to valuable plantings, controlled research indicates that many of the “repellant” plants have no profound impact on the number of beetles landing on the “protected” plants, or on the amount of feeding damage ultimately done. In fact, some evidence suggests that planting some of these plants near the desired plant may result in more feeding (Held, Gonsiska and Potter 2003). On the other hand, planting specific ground covers between rows of certain high value crops, such as blueberries, has been shown to influence the number of adult beetles feeding, and the subsequent number of larvae in the area (Szendrei and Isaacs 2006).

Many biological control agents are available for control of Japanese beetle. However, a major obstacle to the use of these agents in an effective manner is that Japanese beetle is a pest with quarantine significance. Biological control agents generally take several years to become established, with the general range of 10 and 15 years for Japanese beetle numbers to drop (Cappaert and Smitley 2002). Other Scarabaeidae may serve as hosts (Koppenhöffer et al 2000), but due to competition with other natural enemies for native organisms, population levels may not develop that will serve an economic purpose.

While the beetle has a wide host range, there are crops that do not serve well as larval food. These crops, when planted in a rotation with susceptible plants, can retard the development of large populations of Japanese beetle (Fleming 1976).

Japanese beetle has been studied extensively by USDA as well as other researchers. As this is a pest of lawn and garden situations, it is frequently encountered in areas where people have a “zero tolerance” for what they consider pests. In addition, since the insect is primarily considered to be a cosmetic pest, there is a dearth of economic threshold data. Since it is directed primarily at homeowners, the data available may be of a non-scientific nature (http://www.pueblo.gsa.gov/cic_text/housing/japanese-beetle/jbeetle.html), with generalizations regarding when to treat and how to choose a treatment option.

Likelihood of Invasion:

1. Pest History Rating: High

The Japanese beetle was initially confined to a small area in New Jersey. However, control efforts in that area failed, and the beetle subsequently spread throughout the entire eastern U. S. (Fleming 1976). In part, this spread may be due to a lack of natural enemies, and may be accentuated by the expanse of acceptable hosts. The beetle is capable of relatively rapid movement on its own (Fleming 1976), but is also moved through aircraft and other modes of conveyance (http://www.aphis.usda.gov/ppq/manuals/domestic/pdf_files/Japanese_Beetle.pdf).

Japanese beetle adults are apparently attracted to some component of jet fuel (http://www.aphis.usda.gov/ppq/manuals/domestic/pdf_files/Japanese_Beetle.pdf), resulting in a higher risk of introduction at airports, particularly around cargo terminals, where large planes sit for extended lengths of time with cargo bay doors open. As a result of this behavioral characteristic, surveillance trapping is frequently carried out around airports with interstate flights from areas with Japanese beetle.

At the present time, a small population of Japanese beetle is established in Billings. Without control efforts, this population is highly likely to spread to the entire city and to areas outside the city.

2. Quantity of Commodity Imported Rating: Medium

Relatively few commodities come into the state that may be infested with JB. There has been a steady increase in nursery activity in the past decade (MDA reports to Western Horticultural Inspectors Society, 2003, 2005, and 2006), as the population demographics of Montana have changed to encompass more people who desire landscaping. With this has come an increased demand for plants from other states. In addition, some sod for lawns, golf courses, and other areas has also been moved into the state from other areas.

However, over the past six years, Japanese beetle has been detected every year in Billings (Table 2). During 2005, it became apparent that an infestation had developed in the area directly below the Rimrocks, a prominent local feature. In addition, inspection of several cargo aircraft resulted in the detection of no Japanese beetles during 2005.

Table 2. Results of monitoring for Japanese beetle in Montana during the period from 2000 to 2006.

Year	No. JB traps placed	JB collected in traps
2000*	155	0
2001*	151	0
2002*	160	4
2003	584	3
2004	623	3
2005	393	40
2006**		

JB = Japanese beetle adults
*Includes traps located throughout the state.
**Due to lack of funding, the JB monitoring program was modified to a homeowner / volunteer trapping program in the Billings metropolitan area. Airport monitoring was conducted by the Billings office of the USDA APHIS PPQ.

3. Estimated Pest Density per Unit Imported Rating: Low

There have been no reported attempts to quantify the number of Japanese beetle associated with nursery or lawn products, or with aircraft. As a rule, the number of Japanese beetle found on a single aircraft is 1-2 (Japanese beetle conference calls).

4. Likelihood of Surviving Treatment Rating: Medium

Treatment for Japanese beetle in commodities to be transported can be complicated. Balled and burlapped trees and shrubs, and turf grass can be successfully treated for infestations of grubs, however, pupae and eggs are more resistant to insecticides. In addition, larger grubs are more resistant to insecticidal treatment. Adequate treatment generally requires saturation of the entire root ball in the case of balled and burlapped stock, which can be difficult in the case of large plants.

5. Likelihood of Surviving Shipment Rating: Medium
Japanese beetle is recorded as surviving in airplanes, in balled and burlapped stock, turf, and other commodities, particularly from highly infested areas. Larvae generally move down in the soil profile in response to onset of winter conditions and water fluctuations (Fleming 1972). Storage of dry commodities for extended periods of time in sub-zero conditions may impact the beetle negatively but any insulation of the soil, such as snow, will enhance survival. Unfortunately, the high risk commodities such as balled and burlapped stock and turf are likely to be endangered by exposure to the types of conditions that would ensure destruction of the beetles.

6. Likelihood of Moving to a Suitable Climate Rating: Medium
Much of Montana will not provide a suitable climate, in terms of water availability, for the beetle. The egg and early larval stages are susceptible to desiccation (Fleming 1972) and the pupal stage may also be impacted in a negative way by a lack of humidity (Fleming 1972). However, many areas of the state have adequate rainfall or irrigation. These areas also tend to be the areas where farming and population centers are, making the tolerance for the beetle much lower.

7. Likelihood of Finding a Suitable Host: High
Japanese beetle adults are strong fliers, capable of extended flights of up to five miles (Fleming 1972). The host range of the insect as an adult is quite wide, allowing replenishment of reserves through feeding. While the larval feeding range is somewhat more restricted, larvae have been observed feeding on a large number of plants (Fleming 1972, Held, et al. 2003). Since the beetle travels in part on nursery stock, potential for importation associated with appropriate hosts is very high. The tendency to landscape airports with grass plantings and flowering plants also assures a ready supply of host plants for beetles arriving via cargo planes. Movement within the state after introduction will depend in part on the availability of other plants. Movement of nursery materials from infested areas to other areas of the state should be considered a high risk activity for transport of the beetles. Continued trapping, quarantine of infested areas, and certification of pest free status should be considered essential to prevent the spread of this pest.

8. Potential for eradication: Medium
Japanese beetle has been temporarily eradicated from various areas of the United States. At the present time, eradication efforts are ongoing in California, Utah, Oregon, Washington, and Colorado, with varying degrees of success. In part, success depends upon early detection of the pest, as well as total cooperation of the landholders in the infested areas. The areas in Montana that are most likely to experience infestation by Japanese beetle tend to be urban, with large numbers of landholders, which will complicate eradication efforts. In addition, Montana statute places control of pest organisms in the hands of the local governments (7-22-2306 MCA). As a direct result, unless either a State of Emergency is declared by the governor (unlikely in the case of Japanese beetle), or the County Commissioners create a pest control district, government action to control this pest is unlikely. Cooperation by all landholders in an area will be difficult to achieve, although it may happen in certain areas, particularly if neighborhood associations become involved, or a large portion of the land is controlled by a single entity, such as a college or a hospital.

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